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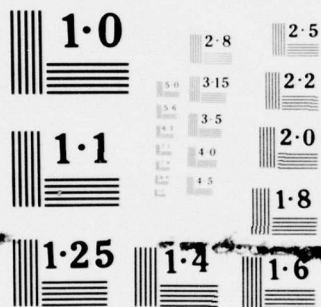
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PROJECT SQUID

TECHNICAL REPORT MICH-18-PU

SUMMARY OF THE PROJECT SQUID WORKSHOP ON TRANSONIC FLOW PROBLEMS IN TURBOMACHINERY

by

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CONTRACT N00014-75-C-1143 NR-098-038

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ABSTRACT

A Workshop on Transonic Flow Problems in Turbomachinery was held at the Naval Postgraduate School, Monterey, California, February 11-12, 1976. Because of the growing need to improve engine performance characteristics, the interest in internal transonic flows has greatly increased. This workshop was held to inform the various workers in the field about the latest work being done and to provide a number of opinions of what important work remains. A volume has been assembled consisting of the thirty-eight papers presented, the discussion following each paper, and the review and discussion sessions at the end of the workshop; this volume, ⁸⁵entitled Transonic Flow Problems in Turbomachinery, edited by T.C. Adamson, Jr. and M.F. Platzer, will be published soon by Hemisphere Publishing Company, Washington, D.C.

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SUMMARY OF THE PROJECT SQUID WORKSHOP ON
TRANSONIC FLOW PROBLEMS IN TURBOMACHINERY

The University of Michigan
Ann Arbor, Michigan
Subcontract No. 8960-22

T.C. Adamson, Jr.

I. INTRODUCTION

The purposes of the meeting described in this report were, first, to assess the current advances in transonic flow analyses and experiments and their applicability in predicting the flow in transonic turbomachines, and, second, to ascertain what work should be done in the future to improve these techniques. The speakers included external and internal aerodynamicists, analytical and computational experts, and experimentalists and theoreticians. The subject matter was only slightly constrained by rather general session subject headings, with the exception that it was decided to limit unsteady flow considerations to the assessment of the effects of unsteady flow on performance. The authors were representative of industry, government laboratories, and universities. A list of authors and their papers for each session is given in the Appendix. These papers, the discussion following each paper, and the reproduction of the review and discussion sessions held at the end of the workshop are contained in a volume entitled, Transonic Flow Problems in Turbomachinery, editors, T.C. Adamson, Jr. and M.F. Platzer, which will be published by Hemisphere Publishing Company in September 1977.

II. DELINEATION OF PROBLEM AREAS: STRUCTURE OF THE WORKSHOP

The general problems associated with transonic flows have been discussed with varying intensity for many years. With the advent of high subsonic Mach number transport aircraft, there has been a great resurgence of effort on transonic airfoil analysis and design. However, the need for high performance jet engines, in both the high subsonic Mach number and supersonic Mach number flight regimes, has also resulted in a great deal of work in internal transonic flows, i.e., transonic flows in rotors and channels. In many respects these internal flows are more demanding than external flows; for example, it is generally necessary to consider three dimensional internal flows, and it is necessary to be much more precise insofar as shock wave position and strength is concerned because of shock reflections off channel or rotor walls. Nevertheless, the fundamental problems are similar, and improvements developed in either area of work are often useful in the other. Hence, in the workshop there was no effort made to group talks having to do with internal or external aerodynamics.

Because of the very complex geometries and upstream flow conditions inherent in flows in turbomachinery, by far the greatest amount of analysis of the transonic flow fields is carried out by computers. Nevertheless, there are many cases where analytical work is of critical importance insofar as understanding of specific flow phenomena is concerned. Moreover, before any numerical computations can be made, it is necessary to

formulate the problem considered. Therefore, in the workshop, there were two sessions on analysis; the first was concerned with the formulation of transonic flow problems to various orders of approximation, and the second with computational methods of solution.

Again, because of geometric and upstream flow condition complexities, most computations are carried out under the assumption that the flow is inviscid. However, there are certain regions in a flow field, where so-called viscous effects are of primary importance; they may, for example, cause flow separation and thus negate the possibility that an inviscid flow field calculation is valid. Hence, the third session of the workshop was on viscous effects on transonic flows, these effects including both those due to boundary layers alone, and those due to shock wave boundary layer interactions.

It is generally agreed that, in general, two dimensional flow fields are not representative of transonic flows in rotors and channels. As a result, a great deal of effort has recently been expended in doing experimental work in three dimensional channels, and in fact in the blade passages of actual rotors. The laser is being employed in the form of a nonintrusive diagnostic tool to make measurements in these passages. In the fourth session of the workshop, which was concerned with experiment and included a review of experimental work in progress, these new diagnostic methods were emphasized.

The fifth and final session of the workshop consisted of a review and discussion in which each of the session chairmen presented a brief review of his session.

III. DEVELOPMENT OF THE WORKSHOP

The Project SQUID Workshop was cosponsored by the Air Force Office of Scientific Research (Lt. Col. R.C. Smith), Naval Air Systems Command (Dr. H.J. Mueller) and the Office of Naval Research (Mr. J.R. Patton, Jr.). It took place at the Naval Postgraduate School, Monterey, California, February 11-12, 1976, and was attended by sixty-seven people from both the U.S. and foreign institutions. The co-organizers and co-chairmen of the meeting were Professors T.C. Adamson, Jr. of the University of Michigan and M.F. Platzer of the Naval Postgraduate School.

The format of the meeting was such that at the beginning of each session there were two or three invited papers of 20 to 25 minutes duration followed by a number of 5 to 10 minute talks covering work in progress. After each presentation, there was a discussion which was recorded. A panel discussion (Session V) was held at the end of the Workshop. These discussions were then transcribed. The formal papers submitted by the authors along with the transcription of all of the discussions form the body of a report of the proceedings⁽¹⁾, and also a bound volume to be published by Hemisphere Publishing Company in September 1977.

IV. OUTCOME

The organization of the Workshop and thus the proceedings was carried out with emphasis on the two goals mentioned previously; thus, the first goal was to assess the current status of analytical and experimental work

⁽¹⁾ Transonic Flow Problems in Turbomachinery, Eds. T.C. Adamson, Jr. and M.F. Platzer, Project SQUID Report MICH-16-PU, 1976, 660 pp. DDC/NTIS ADA-037060.

in transonic flows in turbomachinery, and the second was to attempt to judge what work should be done in the future. In the attempt to reach these goals, participants representing different schools of thought were invited so as to elicit constructive criticisms. This led to discussions, in the area of computational methods in particular, which should prove very useful both to newcomers in the field and to those experts wishing to assess the work of others. Also, many speakers were invited to discuss their work; this, unfortunately, meant long sessions. However, it also meant that more subject material is included in the proceedings; hopefully the trade-off was worthwhile to the participants, who were most patient and cooperative. In any event, it appears that perhaps the first goal was realized. Insofar as the second goal is concerned, the various opinions on research which should be carried out in the future can be found by reading the discussions, in particular the general discussion in Session V. Some specific ideas on this subject are contained also in the editors' concluding remarks. More general comments are given in special remarks by Professor K. Oswatitsch.

The table of contents for the proceedings, attached as an appendix to this report, indicates the overall scope of the Workshop.

Copies of the Proceedings may be obtained from

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and also

- 2) DDC/NTIS
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APPENDIX
Table of Contents
for
Project SQUID Workshop
on Transonic Flow Problems
in Turbomachinery

PREFACE

THIRTY YEARS OF RESEARCH

WELCOMING REMARKS

James R. Patton, Jr.
Herbert J. Mueller
Robert C. Smith

SESSION I - ANALYSIS: BASIC FORMULATION FOR TRANSONIC FLOW
PROBLEMS IN ROTORS

CHAIRMAN: William D. McNally

Introductory Remarks for Session on Basic Formulation for
Transonic Flow Problems in Rotors
William D. McNally

Basic Formulation for Transonic Flow Problems in Rotors
K. Oswatitsch

Three-Dimensional Inviscid Flow Through a Highly-Loaded
Transonic Compressor Rotor
J.E. McCune

Work in Progress

Calculation of 3-Dimensional Choking Mass Flow in Turbo-
machinery with 2-Dimensional Flow Models
Theodore Katsanis

Three Dimensional Transonic Shear Flow in a Channel
Thomas C. Adamson, Jr.

Some Formulation Considerations in 3-D Transonic Flow
Computation
D.S. Paris, A.A. Ganz, and J.F. Liutermoza

Computation of Steady and Periodic Two-Dimensional Nonlinear
Transonic Flows in Fan and Compressor Stages
John Erdos, Edgar Alzner, and Paul Kalben

SESSION II - ANALYSIS: COMPUTATIONAL METHODS

CHAIRMAN: Gino Moretti

Computation of Transonic Potential Flows in Turbomachinery
Earll M. Murman

Finite Difference Procedure for Unsteady Transonic Flows -
A Review
H. Yoshihara

Four Issues in the Computation of Transonic Flows in
Turbomachinery
David A. Oliver

Work in Progress

Comparison of a Finite Difference Method with a Time-Marching
Method for Blade to Blade Transonic Flow Calculations
J. M. Thiaville

Rotational Transonic Internal Flows
E.F. Brown

Application of a Multi-Level Grid Method to Transonic Flow
Calculations
Jerry C. South, Jr. and Achi Brandt

Application of Time-Dependent Finite Volume Method to
Transonic Flow in Large Turbines
C.L.S. Farn and D.K. Whirlow

Finite-Difference Calculations of Three-Dimensional Transonic
Flow Through a Compressor Blade Row, Using the Small-
Disturbance Nonlinear Potential Equation
William J. Rae

Transonic Relaxation Methods
P.R. Dodge

Calculation of Transonic Potential Flow Fields about Complex,
Three-Dimensional Configurations
D.A. Caughey and Antony Jameson

Calculation of Supercritical Flow Past a Double Wedge by
Telenin's Method
Keun Sick Chang and Maurice Holt

Supercritical Cascade Design
David G. Korn

A Navier-Stokes Solution of the Three-Dimensional Viscous
Compressible Flow in a Centrifugal Compressor Impeller
James L. Harp, Jr.

Shock-Fitting in Transonic Flow Computation
M.M. Hafez and H.K. Cheng

Efficiency Gains of Second Order Accurate Methods with Shock
Fitting
Czeslaw P. Kentzer

Solutions to Internal Transonic Flows Via Parametric Differentiation
W. Whitlow, Jr. and W. L. Harris

Perturbation Solutions for Blade-to-Blade Surfaces of a Transonic
Compressor
S.S. Stahara, D.S. Chaussee, and J.R. Spreiter

SESSION III - VISCOUS EFFECTS IN TRANSONIC FLOWS

CHAIRMAN: Robert E. Melnik

On the Prediction of Viscous Phenomena in Transonic Flows
George S. Deiwert

Normal Shock Wave-Turbulent Boundary Layer Interactions in
Transonic Flow Near Separation
T.C. Adamson, Jr. and A.F. Messiter

Interactions of Normal Shock Waves with Turbulent Boundary
Layers at Transonic Speeds
R.E. Melnik and B. Grossman

Work in Progress

Coupled Inviscid/Boundary-Layer Flow-Field Predictions for
Transonic Turbomachinery Cascades
P.R. Gliebe

SESSION IV - EXPERIMENT

CHAIRMAN: Arthur J. Wennerstrom

Review of Experimental Work on Transonic Flow in Turbomachinery
William D. McNally

Flow in a Transonic Compressor Rotor
J.L. Kerrebrock

Work in Progress

Comparison of Prediction of Transonic Flow in a Fan with Flow
Measurements Taken Using a Laser Doppler Velocimeter
A.A. Mikolajczak

Nonintrusive Measurements of the Flow Vectors within the Blade
Passages of a Transonic Compressor Rotor
R. Schodl and H. Weyer

A Transonic/Supersonic Smoke Tunnel for the Investigation of
Cascade Loss Models

William B. Roberts, Thomas J. Mueller, and Vincent P. Goddard

A Laser Velocimeter System for Small Radial Turbomachinery

Peter W. Runstadler, Jr. and Francis X. Dolan

Laser Doppler Velocimeter Measurements in a Two-Dimensional
Transonic Flow

H. Doyle Thompson

Real Time Measurements in a Transonic Compressor

R.P. Shreeve

A Comparative Evaluation of Numerical and Experimental Cascade
Data

R.A. Delaney

The Effect of Leading-Edge Thickness on the Bow Shock in
Transonic Rotors

F.A.E. Breugelmans

SESSION V - REVIEW AND DISCUSSION

CHAIRMAN: Max F. Platzer

Review of Session I

W.D. McNally

Review of Session II

G. Moretti

Discussion - Sessions I and II

Review of Session III

R.E. Melnik

Discussion - Session III

Review of Session IV

A.J. Wennerstrom

Discussion - Session IV

CONCLUDING REMARKS

Some Remarks on Present and Future Research Tasks in Fluid
Mechanics

K. Oswatitsch

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1. REPORT NUMBER MICH-18-PU	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SUMMARY OF THE PROJECT SQUID WORKSHOP ON TRANSONIC FLOW PROBLEMS IN TURBOMACHINERY.		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) T.C. Adamson, Jr.		8. CONTRACT OR GRANT NUMBER(s) N00014-75-C-1143
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Aerospace Engineering The University of Michigan Ann Arbor, Michigan 48109		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR-098-038
11. CONTROLLING OFFICE NAME AND ADDRESS Project SQUID Headquarters, Chaffee Hall Purdue University West Lafayette, Indiana 47907		12. REPORT DATE July 1977
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Office of Naval Research Department of the Navy Arlington, Virginia 22217		13. NUMBER OF PAGES 22
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) This document has been approved for public release and sale; its distribution is unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Workshop Transonic Flow Turbomachinery		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A Workshop on Transonic Flow Problems in Turbomachinery was held at the Naval Postgraduate School, Monterey, California, February 11-12, 1976. Because of the growing need to improve engine performance characteristics, the interest in internal transonic flows has greatly increased. This workshop was held to inform the various workers in the field about the latest work being done and to provide a number of opinions of what important work remains. A volume has been assembled consisting of the thirty-eight papers presented, the discussion following each paper, and the review and discussion sessions at the end of the		

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workshop; this volume, entitled Transonic Flow Problems in Turbomachinery, edited by T.C. Adamson, Jr. and M.F. Platzer, will be published soon by Hemisphere Publishing Company, Washington, D.C.

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